# THE FEEDING OF *RUTILUS RUBILIO* (BONAPARTE) (PISCES, CYPRINIDAE) IN LAKE TRICHONIS, GREECE.

by

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RESUME. – L'alimentation du *R. rubilio* dans le lac oligotrophe grec Trichonis, durant les années 1978-1979 a été étudiée. L'alimentation s'effectue le jour et l'activité alimentaire se ralentit en hiver et durant la période de reproduction. Plus de 43 types de proies constituent son régime alimentaire. Les poissons de petite ou moyenne taille (LF ⟨ 159 mm) sont euryphages, mangeant aussi bien des végétaux que des anaimaux, tandis que les plus grands sont sténophages, consommant surtout le mollusque *Dreissena polymorpha*.

SUMMARY. – The feeding of *R. rubilio* in the oligotrophic Greek lake Trichonis during 1978-1979 was examined. Feeding took place at daytime and the feeding activity declined in winter and during the period of reproduction. More than 43 kinds of food were included in the diet. Small and medium sized fish (FL ⟨ 159 mm) were euryphagous, feeding on both plant and animal food, while the largest ones were stenophagous, mainly consuming the mollusc *Dreissena polymorpha*.

Key-words: Pisces, Cyprinidae, Rutilus rubilio, freshwater fish, Greece, feeding behaviour.

As it is generally accepted, the kind of food has been considered as one of the factors that have determined the evolution of the morphological and physiological feeding characters of fish. The quantity of food also influences certain life parameters of the fish population, such as growth, quality and quantity of the sexual products, survival, behaviour, etc. Thus, the study of the feeding habits of fish contributes not only to aspects of fish biology, but also to a better management of the exploited populations.

Despite the geographical distribution of *R. rubilio* in Greece, Albania, Jugoslavia and Italy, our knowledge of its feeding characteristics is confined to lake Trasimeno (Cianficconi, 1959, 1960, 1961 and 1966 ; Calderoni, 1967). In particular, information about the food and feeding habits of the populations inhabiting Greek waters is totaly lacking. These populations are primarily found in lakes and rivers in central and northern Greece (Economidis, 1973) and are used locally as food.

Data are provided in this study about the feeding intensity feeding spectrum and daily feeding pattern of *R. rubilio* in the oligotrophic Greek lake Trichonis.

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## MATERIAL AND METHODS

The material used in the present study was collected from lake Trichonis at monthly intervals from March 1978 to February 1979. The fish were caught with surrounding nets (mesh size 22 mm) and beach seines (mesh size 0.8 mm at the sac). Due to the short time of fishing (30 min. for the nets, 10 min. hauling with the gear), the fish were trapped when actively feeding. Monthly samples were always taken from the same position and at about the same time.

The study of the diurnal pattern of feeding periodicity was based on 256 individuals (FL, 100-140 mm) collected at three hour intervals in March, June and September at the same station. All samples were preserved in a 7 % solution of formalin in fresh water. In the laboratory, the fish were measured (FL, in mm), weighed (total and net weight, in g), the length of the alimentary canal was recorded and the maturity stage of the gonads was assessed (Nikolsky, 1963). 10-15 scales were also removed for age determination.

The alimentary canal of each individual was separated in three digestive parts (Calderoni, 1967) and the segregation of the ingested food was made separately for each part. Afterwards, the tissues, the mucus and the excess moisture were removed, the food particles were gathered and weighed to the nearest 0.01 g separately for each part.

The contribution of each prey to the total diet was estimated in 1279 individuals of a length of 60-258 mm, 74.8 % of which being between 100-159 mm. The estimation was made using an especially prepared pyrex dish, divided into 576 small squares (3.3 x 3.3 mm each). Food was spread on the dish and similar items were placed in the same squares. Following this procedure for the food of each digestive part separately, the area covered by each food type was calculated and the respective areas from all three digestive parts were added.

The treatment of the feeding data was made separately for each sampling period and size category or sex. The numerical contribution of each food item was estimated from the number of squares covered by this food item in relation to the total number of squares occupied by food particles. The frequency of occurrence of each item was calculated from the number of digestive tracts containing this item compared to the number of tracts containing food. The percentage of fish with empty guts was also estimated. In order to reduce the effects of variations in body size and to allow comparisons between size groups, the weight of the gut contents has been expressed as a proportion of the fish weight (%). To test whether the diet of fish of different sizes or sexes is different, the percentage similarity of their gastrointestinal contents was calculated using the Sorigin's method (in Borutsky *et al.*, 1961). According to this method, the percentage composition of the several food items in the diet for each size category or sex was estimated and the smaller percentage values were summed up.

The presentation of the results is made in the form of circular diagrams (Fig.3), in which the radius represents the frequency of occurrence, the arc the amount of each food item as a percentage of the total diet and the radius of the broken circumference the square root of the fullness index of the gut (Borutsky *et al.* 1961 ; Hureau, 1970).

## RESULTS

### Rate of feeding

*Seasonal variation of feeding*

The fullness index of the grouped data fluctuated around 0.32-2.76 %, depending on the season and the size of the fish. The lowest values were obtained in December (0.45-5 %) and March (0.32-6 %) for the largest fish (Fig. 3). The decline in the fullness index in March is due to the spawning activity. In general, during the period of reproduction, the fullness index was dependent on the stage of sexual maturity. Individuals at stages IV and V fed very little or not at all (0.19-0.47 %), while, after spawning, individuals at the maturity stages VI and II fed intensively (0.94-1.85 %). Presumably, the reduction of the feeding rate in fish of stage V is associated with the increase of the volume of the gonads, which thus limit the volume of the visceral cavity. In contrast, the increase of the fullness index after spawning is necessary for the fish to make up for losses of stored energy during period of reproduction (Shulman, 1972).

Compared to the period of intense feeding (summer, where only 1 % of fish contained no food), an increased proportion of the sampled population had empty guts during the period of reduced feeding (December 40.5 %, March 22.6 %).

*Diurnal changes of the feeding rate*

The examination of the daily pattern of the feeding showed that *R. rubilio* (FL, 100-140 mm) is a day-feeder (Fig. 1). In June and September, at high water temperatures (17.2° C and 22.1° C respectively), two periods of elevated feeding activity (07.00 and 22.00 h in June, 10.00 and 19.00 h in September), were detected. In contrast, feeding during March, which is the period that *R. rubilio* begins spawning, took place at a water temperature of around 11.1° C and the fullness index showed only one evening peak at 16.00 h.

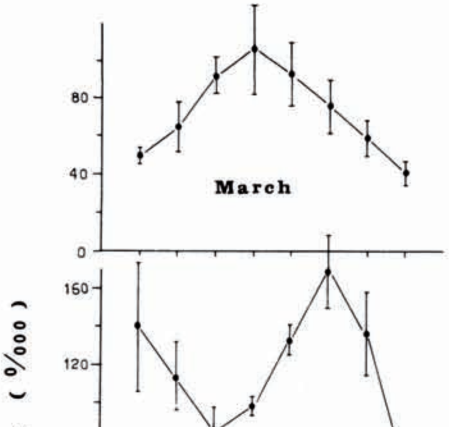
Figure 2 presents the percentage values of the several food items over a daily cycle for three sampling periods. Molluscs (bivalves and gastropods) predominated in the morning diet, while algae and macrophyts were more important in the evening and night hours.

### Qualitative and quantitative composition of the diet

The degree of similarity between sexes and adjusted size groups was high (67-94 %), thus the data were grouped and presented separately for fish of 80-119, 120-159 and 160-259 mm.

The feeding spectrum of *R. rubilio* consisted of more than 43 kinds of food and included both plant and animal organisms. The diet varied from month to month and while the food of small and medium sized fish (FL, 60-159 mm) consisted of 7-22 kinds, that of large fish (FL > 160 mm) consisted of only 1-6 kinds.

The kind and amount of food taken changed with the period of the year and the size of the fish. Fish of small and medium size presented the highest fluctuation



ig. 1 – Diurnal changes of the fullness index in three sampling periods. Vertical lines show the 95 % confidence limits.

in the qualitative and quantitative pattern of feeding (Fig. 3). Vegetable food (algae, macrophytes and diatoms) contributed significantly to the diet of fish of small and medium size, especially during the periods when these fishes were caught near the shore (spring, summer and autumn). In winter, when the fish were caught at greater depths, the vegetable items were less important, while molluscs contributed more to the composition of the gut contents.

Plants like *Cladophora, Spirogyra, Zygnema* and *Oedogonium* were appreciably taken by *R. rubilio* (Frequency of occurrence F.O. from 16.9 % to 83.9 %, percentage by number N% from 16.5 % to 38.2 %). *Chara* was the most preferred food item from June to September with F.O. 37.3-80 % and N% value 9.9-34.6 %. Other plants of minor importance were *Sparganium, Potamogeton* and *Nitella*, with corresponding F.O. values of 13.6-26.6 %, 5.6-17.5 % and 1.2-2.3 % respectively. Diatoms predominated in the diet at the same time as the plants, with F.O. values

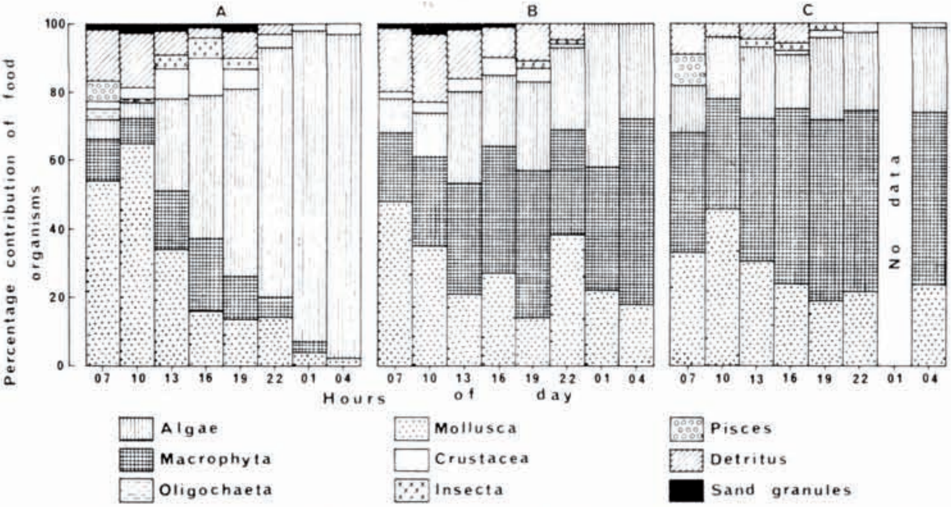


Fig. 2. – Diurnal changes of food composition in *R. rubilio* in March (A), June (B) and September (C) 1978.

of 45-100 % in spring and summer. Important diatoms in the diet were *Cyclotella, Dinobryon, Peridinium, Ceratium, Cymbella* and *Pinularia*. Decomposed plant material (detritus) had a high F.O. value (75.8-100 %) in the period from April to August.

Molluscs (the bivalve *Dreissena polymorpha* and gastropods) were always taken in large quantities by the older fish, while they contributed significantly to the diet of the small and medium sized individuals only in the priod from October to February (Fig. 3).

The increased consumption of bivalves with increasing fish size is clearly shown in Fig. 4. This dependency may be associated with the strengthening of pharyngeal teeth in the growing fish, which enable hard organisms like *D. polymorpha* to be crushed.

Among bivalves, the highest frequency of occurrence was found for *D. polymorpha* (78.8-100 %) and the lowest for *Unio pictorum* (2.4-33.3 %) and *Pisidium* (3.6-22 %). The preference for gastropods was seasonally variable among the small and medium sized fish, presumably owing to their migrations. The highest frequency of occurrence was observed in the period from October to February, with values of 44.4-57%, 24.4-38.9%, 32.6-48.8%, 13.3-31.1% and 9.3-14.6% for the species *Bythinia tetraculata, Valvata* sp., *Theodoxus fluviatilis, Viviparus viviparus* and *Bythinella* sp. respectively. In contrast, frequency of occurrence values for *Radix peregra, Radix auricularia* and *Planorbis carinatus* were higher for the period between March and September, when *R. rubilio* lives in shallower water (37.6-51.5%, 22.6-43.2% and 21.4-49.1% respectively).

Of minor importance was the contribution of other benthic animal, such as *Asellus aquaticus* (N% 0.1-0.2%), *Tubifex tubifex* (N% 0.1-1.1%) and *Gammarus* sp. (N% 0.1-2.6%).

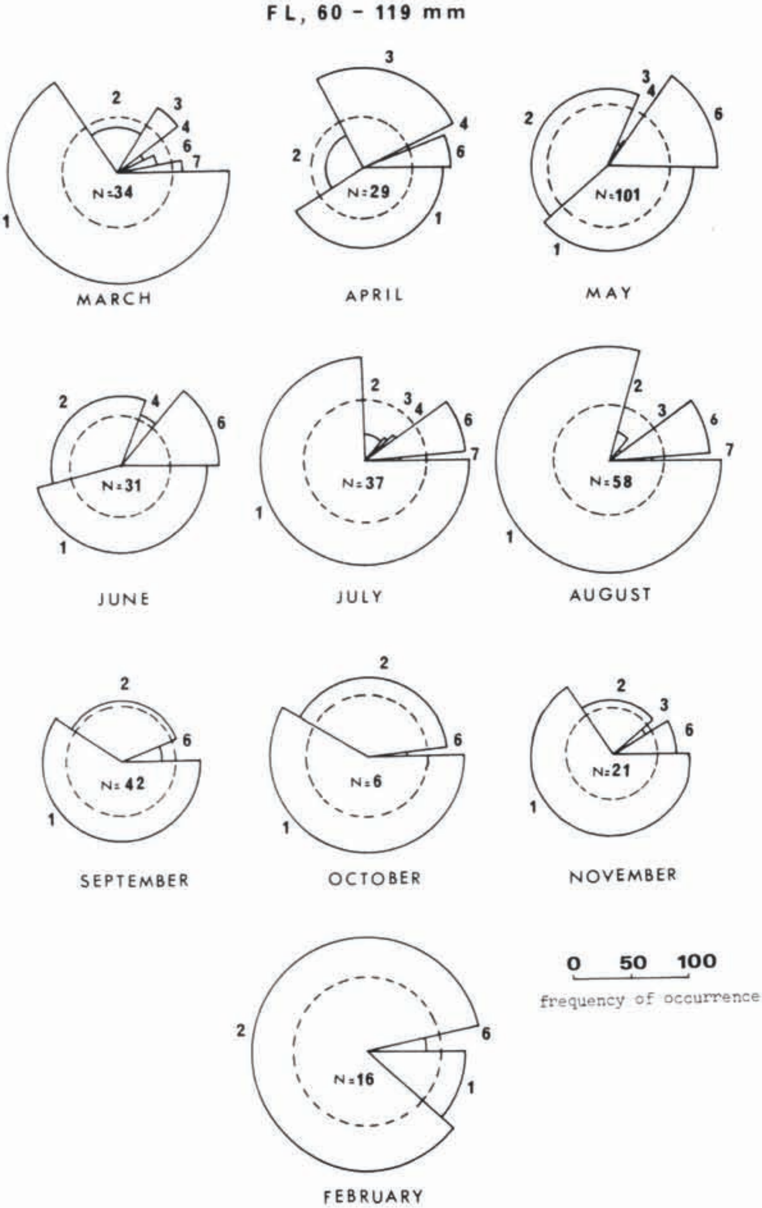

FL, 60 - 119 mm

Fig. 3. – Feeding spectrum of *R. rubilio* during 1978-1979 for different groups of body size. 1. – Aquatic plant organisms; 2. – Mollusca; 3. – Crustacea; 4. – Insecta; 5. – Pisces; 6. – Detritus; 7. – Sand granules.

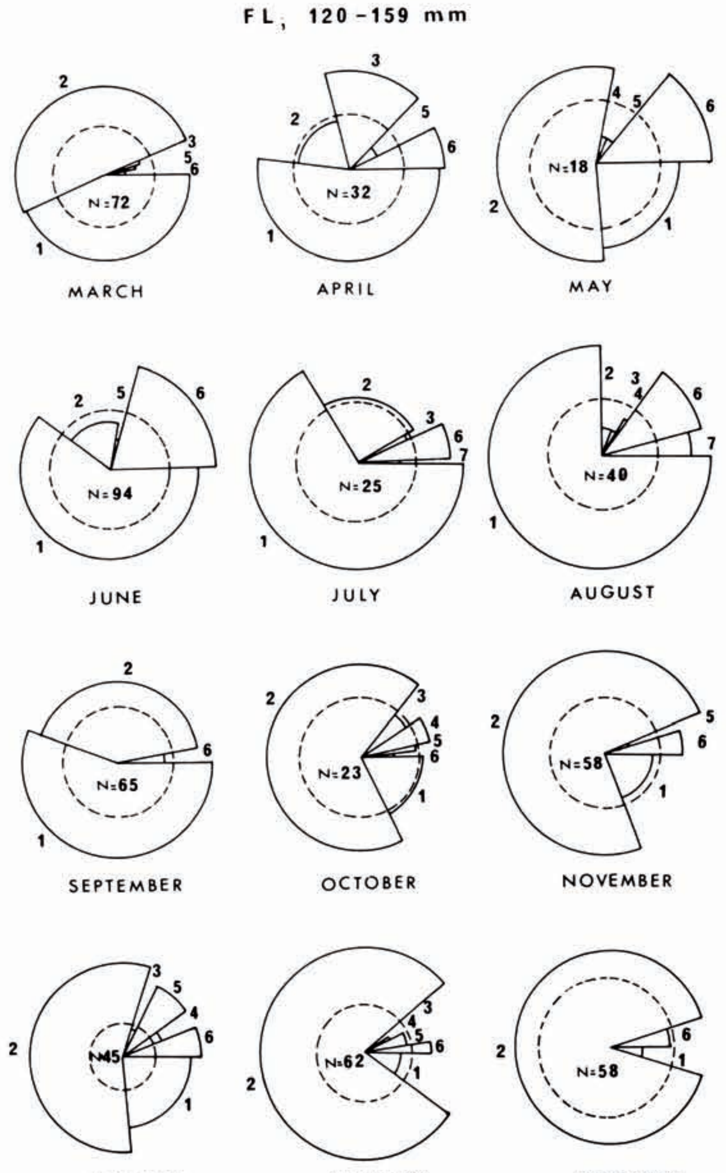
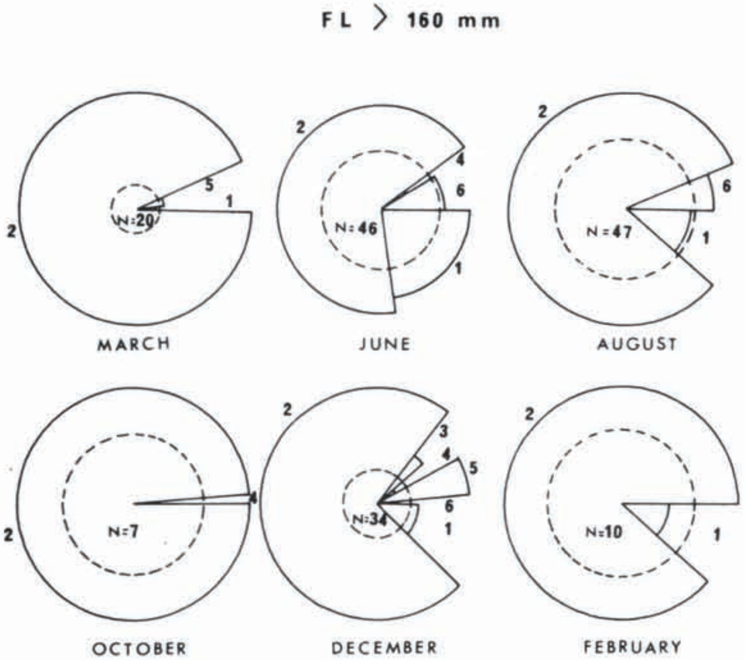


Fig. 3 (continued)

Zooplankton was rarely taken by *R. rubilio* (N% 0.1-15.5%), the highest values being found for cladocerans (*Daphnia longispina, Daphnia hyalina, Bosmina longirostris* and *Diaphanosoma brachyurum*, copepods (*Cyclops* sp.) and larval forms of *D. polymorpha*.

The importance of insects in the diet of *R. rubilio* was very limited. Few larvae of *Chironomus* sp. and *Odonata* were detected and a small number of adult forms



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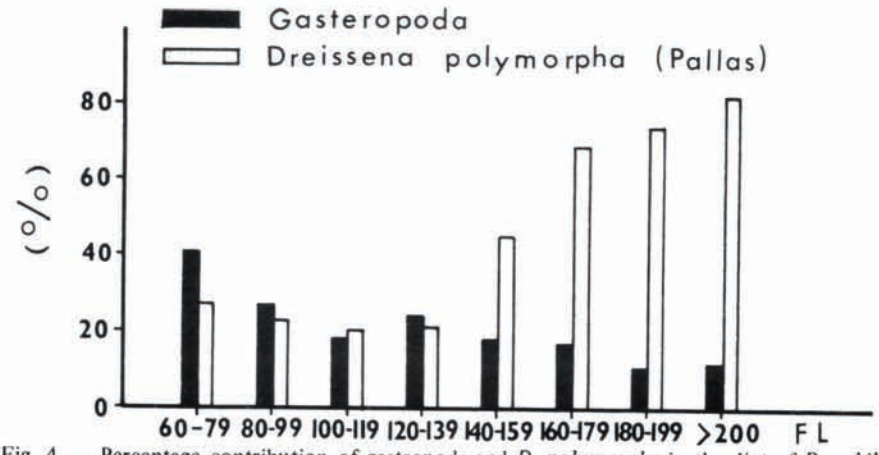

Fig. 4. – Percentage contribution of gastropods and *D. polymorpha* in the diet of *R. rubilio* according to body size over the period of study.

(Diptera and Coleoptera) was taken in spring and summer.

A very small number of Hydrachnellae, *Spongia* sp., Hirudinea, as well as sand granules, were also found.

In 1-37.5% (F.O) of the guts of the fish examined, juvenile fish of the species *Rutilus alburnoides hellenicus*, *Gobius canestrinii* and *Blennius fluviatilis* were found.

## DISCUSSION

Like in all fish species, the kind of food taken changes throughout the year and also depends on the size of the fish. It was not possible to find out at what size young fish start to feed on benthic organisms. According to Calderoni (1967), fish at age $1^+$ feed on planktonic organisms during summer in lake Trasimeno. At the same time, in lake Trichonis, fish at equivalent life stages feed predominantly on vegetable matter. This comparison may lead to the assumption that the early transition to bottom feeding in lake Trichonis in due to the oligotrophic conditions in this lake.

The predominance of either animal or plant organisms in the diet of the fish of small and medium size (FL $<$ 159 mm) presented seasonal fluctuations, probably connected to the seasonal succession of the benthic communities and to the migrations of the fish. Other published information similarly indicates the importance of the plants in the summer diet (Cianficconi, 1959 and 1960).

The particular feeding characteristics of *R. rubilio* are in agreement with the relationships between the alimentary canal size and the body size, which is usually considered as a reflection of the feeding adaptation towards plant, animal or mixed food (Borutsky *et al.*, 1961). In *R. rubilio*, the ratio of the gut to body sizes fluctuated around the unity, indicating an adaptation towards mixed feeding. Carnivorous feeding, characteristic of larger individuals and mixed (carnivorous-herbivorous) feeding, of small and middle sized ones, are probably the result of differences in food availability for fish of different sizes in lake Trichonis. The data provided by Koussouris (1981), Koussouris and Puch-Tomas (1982), Koussouris and Diapoulis (1982) on the biomass and species composition in this lake, show that molluscs, algae and macrophytesare relatively better represented in the lake than other benthic animal groups and zooplankton, fact which probably explains the predominance of these taxa in the diet of *R. rubilio*. It is characteristic that *D. polymorpha* occurred during the period 1975-1978 in the SW and NE part of the lake at a level of abundance 160-440 individuals/$m^2$ while at the same period, the zooplankton concentration was only 0.002-0.007 g/$m^3$ dry weight (Koussouris, 1981). Presumably, the abundance of *D. polymorpha* led the larger individuals (FL $>$ 160 mm) to stenophagy, while the limited quantities of zooplankton led the smaller individuals to euryphagy. According to Nikolsky (1965) and Zubenko (1979), when food is abundant, the feeding spectrum of the fish becomes narrower, while it becomes broader under conditions of poor food availability.

The daily change of the feeding rate observed in this study must be considered as a biological phenomenon connected to the daily pattern of moving activity of the fish, this being influenced directly by biotic and abiotic factors (Leshcheva, 1967). Undoubtedly, the favourable conditions of the abiotic environment during long periods in lake Trichonis (Koussouris, 1981) in conjunction with the lack of a serious degree of interspecific competition and the absence of day-feeder predators (potential predators on *R. rubilio* are the fish species *Anguilla anguilla* and *Silurus aristotelis*, which are night-feeders), afford favourable conditions for the intake and assimilation of food. The low caloric value of the organisms used as food (molluscs, algae and macrophyta) is compensated by a higher feeding rate, which is demonstrated by the high average values of the fullness index.

In conclusion, *R. rubilio* should be considered as a species with a high feeding plasticity which manages, through its broad feeding spectrum and ability of transition to the food organisms available under various circumstances, to maintain itself at a satisfactory population level, despite the increased fishing mortality experienced in the recent years.

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